Chapter 2

Guidelines for Accommodating Pedestrians on Roadways

1. Sidewalks

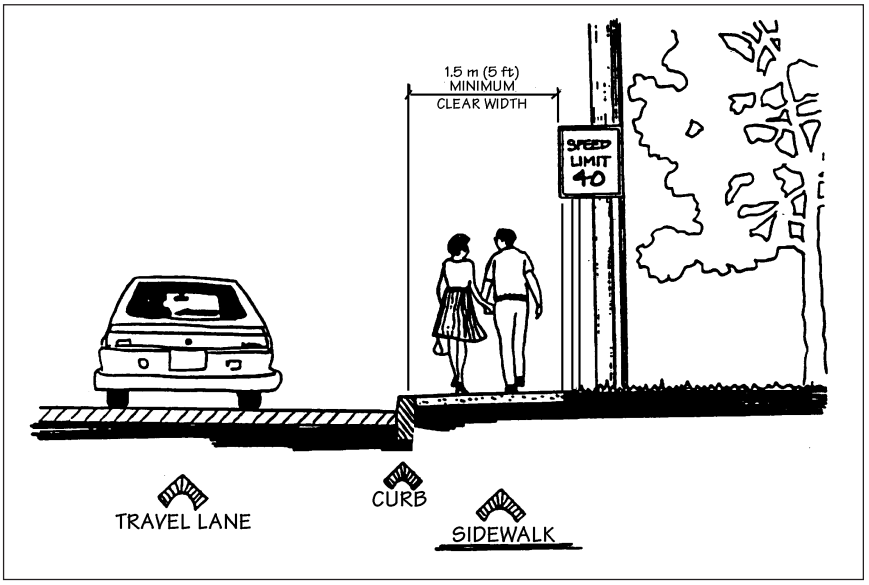
The minimum clear width of all sidewalks in Centers and where urban or suburban conditions apply (such as in PA1 and PA2), should be 1.5 meters (5 feet) exclusive of the curb (except on bridges where the sidewalk width will include the curb width). The 1.5 meter (5 feet) minimum clear width allows for safe and convenient pedestrian and handicapped travel through the following characteristics:

- Allows the sidewalk to adequately serve a collector function; accommodating pedestrian volumes and turning movements to and from adjacent properties.
- Allows persons with strollers, carriages or shopping carts or persons in wheelchairs or using walkers to easily pass each other.
- Provides queuing space for pedestrians at street corners and crosswalks.
- Allows two persons to travel abreast or pass.
- Provides space for children with tricycles, wagons or skates and provides space for other childhood games and activities while accommodating pedestrian use.

This clear width should be free of all trees, signs, utility poles, hydrants, parking meters, and other similar appurtenances. See Figures 7 and 8. The minimum vertical clearance to ceilings, sign panels and other overhead obstructions where pedestrians walk should be 2030 millimeters (80 inches).

The installation of sidewalks immediately adjacent to the curb is both uncomfortable and undesirable to pedestrians. They should only be placed there when severe right-of-way constraints exist.

Where sidewalks are adjacent to a parking lane, an additional 0.6 meters (2 feet) of width is required to compensate for the opening of car doors. See Figure 9. The minimum paved width, in this case, would then be 2.1 meters (7 feet) exclusive of the curb.

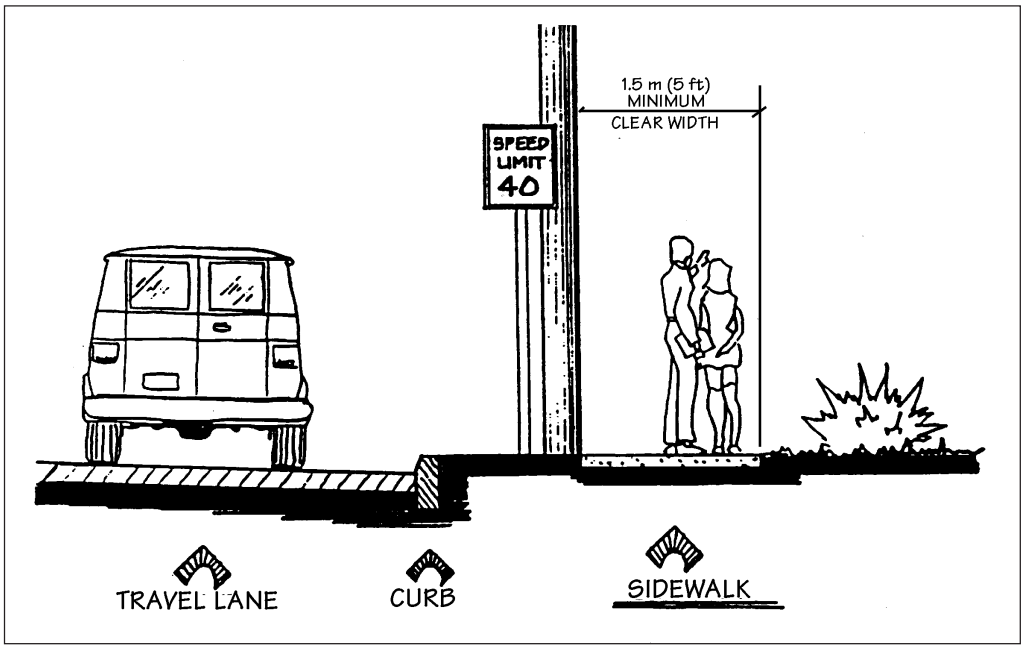


Source: Highway Design Manual, New York State Department of Transportation

Figure 7
Minimum Clear Width of Sidewalks

Figure 8

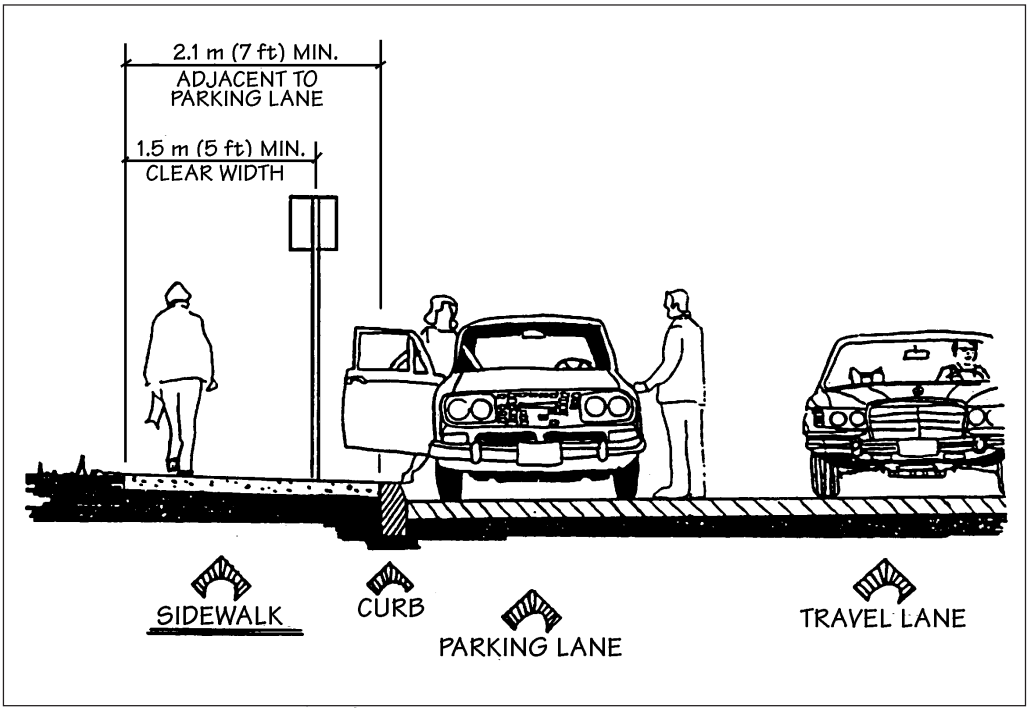
Minimum Clear Width of Sidewalks



Source: Highway Design Manual, New York State Department of Transportation

Figure 9

Sidewalks Adjacent to Parking Lane



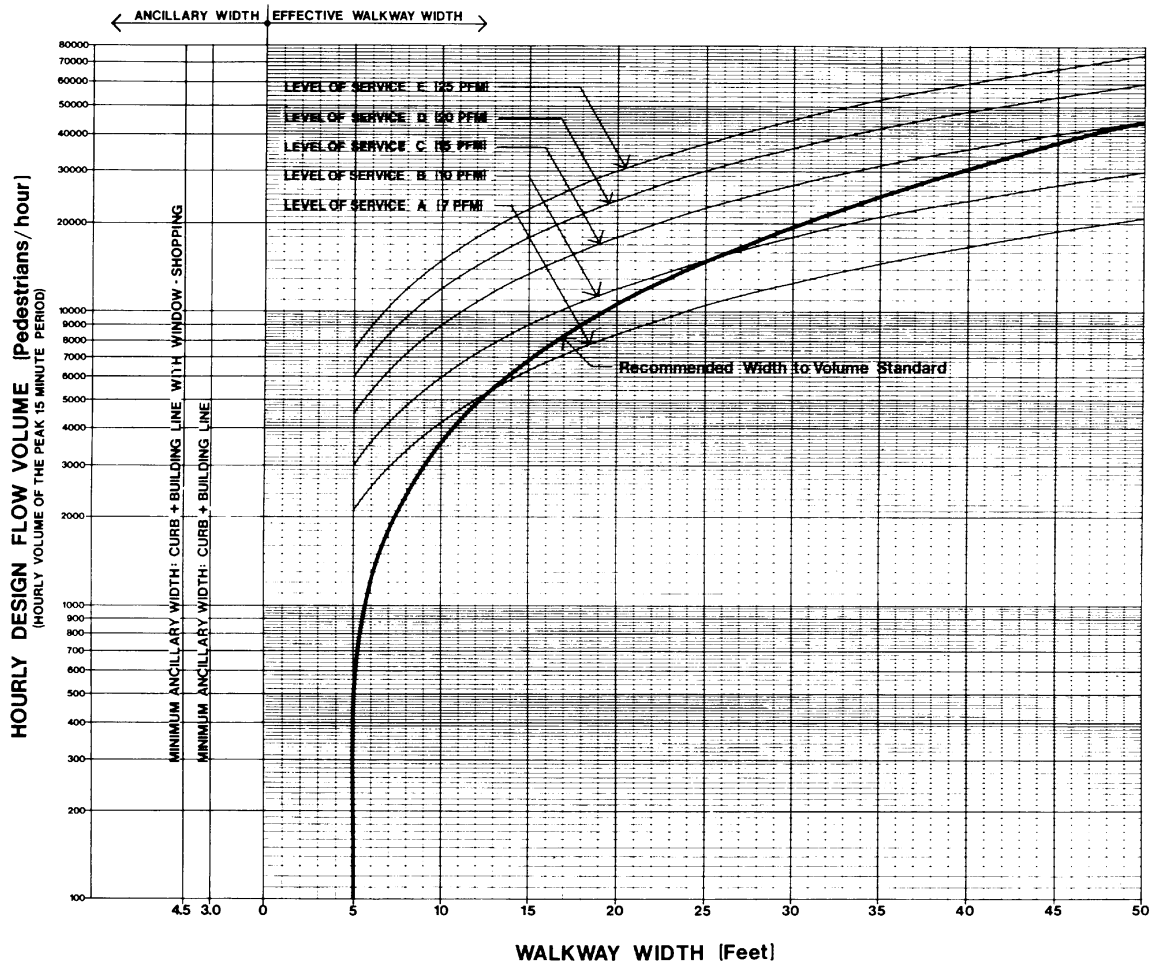
Source: Highway Design Manual, New York State Department of Transportation

Every attempt should be made to design and construct a sidewalk free of obstructions. Every attempt should be made to place obstructions such as signs in the utility strip and not in the sidewalk. Often obstructions can be moved to adjacent property by obtaining easements or purchasing right of way. If they cannot be placed on the utility strip or removed, the sidewalk should be widened by the width of the obstruction.

The above comments apply in situations of light pedestrian traffic typical in suburban, fringe or rural planning areas. However, in Metropolitan Planning areas and in Centers, and especially in downtowns, sidewalks wider than 1.5 meters (5 feet) clear width must often be provided.

While pedestrian capacity analysis techniques described in the 1994 Highway Capacity Manual can be used to evaluate the widths of sidewalk required to accommodate higher levels of pedestrian flow, a more direct source is presented in Figure 10. Using this graph requires that pedestrian volumes be known. Data on existing or projected pedestrian volumes is usually not available, and generally volumes are not used as threshold criteria. However, where such data are available or can be generated, Figure 4 relates sidewalk dimensions to these volumes.

Figure 10
Hourly Design Flow Chart



Source: A Pedestrian Planning Procedures Manual, FHWA, 1979

Note: See Metric Conversion Tables in Appendix

Note that in addition to the effective walkway width, the ancillary walkway width (in which clearance requirements for buildings, curbs, window shoppers, trees, parking meters, hydrants, benches, etc. occur) must be added to yield the total sidewalk width. Figure 11 illustrates the derivation of these dimensions. In heavy pedestrian traffic areas, such as in the Central Business District (CBD), the utility strip should be replaced with additional sidewalk for maintenance purposes. This added sidewalk could be of a porous material, such as stone or brick, that can be easily removed and replaced. An exception should be allowed for landscaping areas.

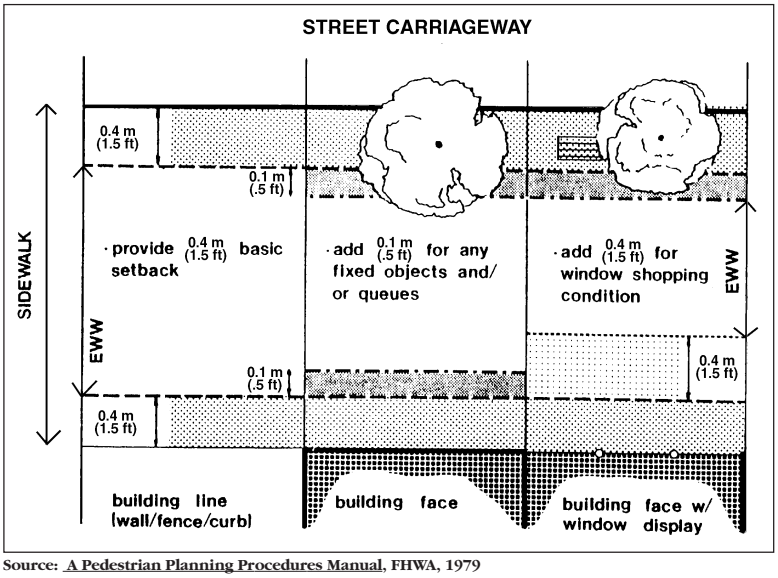
The increased sidewalk needs apply most obviously to traditional "downtown" main streets; these standards, however, can also be used in larger suburban activity centers in either existing or planned regional cores where some increased pedestrian activity and continuity is a goal of the land use layout and the street system.

In areas with insufficient right-of-way to provide the standard 1.5 meter (5 foot) sidewalk, the following alternatives are offered.

- Use a reduced sidewalk width. However, a width of less than 0.9 meters (three feet) is too narrow for a wheelchair and also violates ADA regulations.
- Use a 0.6 meter (2 foot) utility strip with sign posts against the sidewalk or with signs behind the sidewalk.
- When traffic conditions permit, construct roads with narrower travel lanes to provide enough space for the sidewalk.
- Place sidewalk against curb. Some consideration should be given to installing a barrier curb between travel lanes and sidewalks for higher speed roads, particularly in school zones. AASHTO requires that sidewalks placed against curbs be a minimum of 1.8 meters (six feet) wide.
- Prohibit on-street parking, or single side parking, to make more of the existing right-of-way width available for a sidewalk.

In areas outside schools and other major pedestrian generators, the minimum width should be 2.4 meters (8 feet), to allow for gathering and movement needs. In Centers, sidewalk width and placement should be guided by Figure 11, using a minimum effective walkway width (EWW) of 1.5 meters (5 feet) and an overall minimum of 2.4 meters to 3.0 meters (8 feet to 10 feet) depending on edge conditions at the curb and building line. In downtown areas, an EWW of 2.2 meters (7.5 feet) and a total of about 3.9 meters (13 feet) is more appropriate.

Figure 11
Ancillary Walkway Width Requirements



Source: A Pedestrian Planning Procedures Manual, FHWA, 1979

2. Walkway Placement Within the R.O.W.

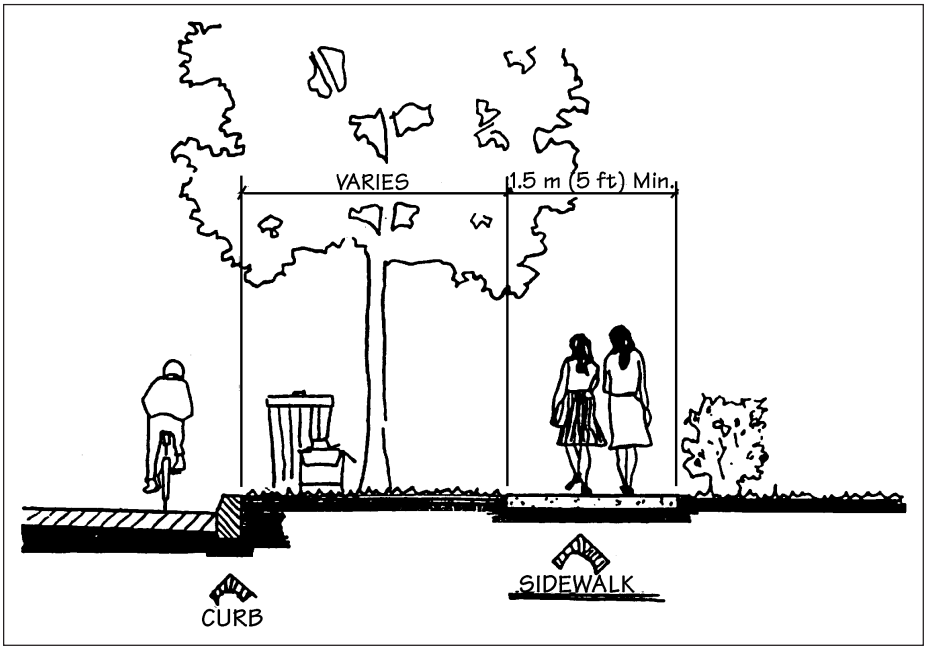
The setback distance of the sidewalk from the roadway is an important safety and design factor. Sidewalks too close to high-speed traffic discourage pedestrian travel due to the high noise level and perception of hazard. Wider setbacks, therefore, add to the convenience and perceived safety of pedestrian travel and should be used whenever possible. Increasing the setback distance has the added advantage of providing room for plantings and utilities and facilitates the design of curb ramps at intersections. However, installing a sidewalk on the very edge of a road is preferable to not having any sidewalk at all.

The desirable minimum space between edge of sidewalk and back of curb is 1.2 meters (four feet), although 2.4 meters (eight feet) or more is the preferred width on all but low traffic volume streets and roads. See Figures 12 and 13. This space accommodates snow storage and is generally grassed and planted with street trees. This space must be planned and designed to avoid clutter and visual screens which can contribute to safety problems. This width provides room for the majority of signs 915 millimeters (36 inches) or less without overhanging the street or sidewalk. Raising the signs to a 2.1 meter (seven foot) minimum clearance prevents most signs from being damaged by vehicles and impeding pedestrian travel. Furthermore, this space accommodates the following:

- Affords pedestrians walking or playing on the sidewalk greater protection.
- Allows storage space for trash and leaf collection and snow storage.
- Allows space to accommodate grade changes so that sidewalk grade variations at driveways are minimized.

The minimum width of a street tree planted strip should be 1.2 meters (four feet). Whenever widths less than 1.2 meters (four feet) are necessary, the strip should be at least 0.6 meters (two feet) wide to be seeded or sodded or it may be paved. Where widths less than 0.6 meters (two feet) are necessary, the strip should be paved.

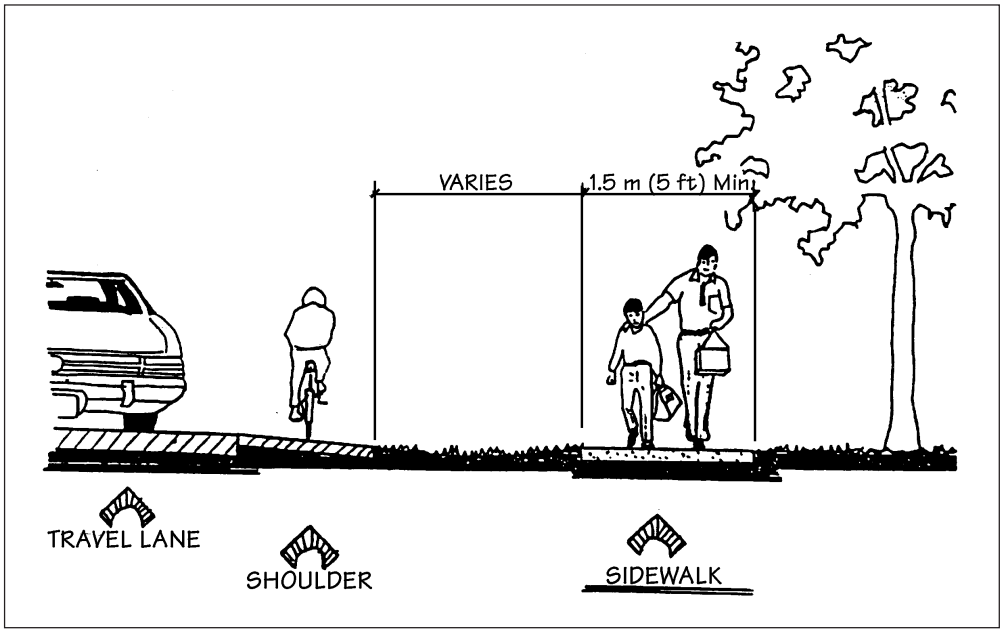
When a minimum 1.2 meter (four foot) strip is not available, consideration can be given to providing tree planting behind the sidewalk, even if off the right-of-way. If off the R.O.W., property owner permission or easement is required before planting.



Source: Highway Design Manual, New York State Department of Transportation

Figure 12
Sidewalk Distance from Travel Lane

Figure 13
Sidewalk Distance from Travel Lane



Source: Highway Design Manual, New York State Department of Transportation

The installation of sidewalks on roadways without curb and gutter (rural section) creates several design, safety, and maintenance problems. The concern becomes how wide the clear zone or offset should be from the roadway. For installation of sidewalks on these roads, the design engineer should:

- Place sidewalks at the right-of-way line in sections of roadways without curbs and gutters.
- Consider potential sight restrictions due to vegetation and buildings.
- Consider the location of any drainage ditches. The pedestrian has little room for escape if the sidewalk is between the roadway and drainage ditch. If the sidewalk is behind the ditch, the ditch helps to redirect an out of control vehicle in a path parallel with the roadway. The pedestrian also has the opportunity of escaping onto private property.

3. Shoulders

Where sidewalks are not warranted, shoulders are generally considered adequate for pedestrian use when paved and at least 1.2 meters (four feet) wide.

Paved shoulder widths beyond 1.2 meters (four feet) are desirable and should be considered when one or more of the following conditions exist:

- Motor vehicle speeds exceed 65 km/h (40 mph)
- The percentage of trucks, buses and recreation vehicles exceeds 5%.
- Bicycle use of the shoulder is more than occasional.
- Pedestrian volumes are high, or groups of pedestrians typically travel together (e.g., routes to school).

Paved shoulder widths less than 1.2 meters (four feet) should be considered only on highways with AADT's of 2000 or less, with speeds less than 65 km/h (40 mph) and with only occasional pedestrian traffic. Project reports should support the decision to provide a shoulder less than 1.2 meters

(four feet) wide by including appropriate discussion concerning existing and expected pedestrian and motor vehicle traffic, relevant highway geometries, accident history and similar applicable data.

Lightly travelled rural roadways and suburban streets having an AADT less than 1200 seldom require a sidewalk or shoulder to accommodate pedestrians.

Figure 14 illustrates a high speed suburban arterial highway, provided with a 3.0 meter (10 foot) paved shoulder. Pedestrians are able to walk far enough away from the traffic lanes to achieve a reasonable level of safety. Even though the right-side shoulder was designed primarily for vehicular accommodations and safety, it also benefits pedestrians. It is recommended that paved shoulders at least 1.2 meters (four feet) in width be provided on all roadways within 8 kilometers (5 miles) of an urban area, specifically in response to bicycle and pedestrian needs. Figure 15 illustrates such a cross section on a two-lane road. Where sufficient shoulder width cannot be provided, separate paths are needed. Figure 16 illustrates a cross section with a narrow shoulder, but a separate pedestrian path. Because of the alternative path provided, the shoulder width is less of a concern.

Source: Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas, Transportation Research Board, 1987

Figure 14

High speed suburban arterial with 10-ft paved shoulder

Source: Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas, Transportation Research Board, 1987

Figure 15

Four-foot paved shoulders to accommodate pedestrian and bicycle traffic

Source: Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas, Transportation Research Board, 1987

Figure 16

Cross section with narrow shoulder but separate pedestrian path

4. Intersections

Generally the most concentrated area of pedestrian activity occurs at street intersections, especially in business districts. Not only do pedestrian flows intersect each other at these locations but these flows are interrupted by vehicular cross traffic and are exposed to vehicular turning movements. Since these areas have higher concentrations of pedestrians and cross traffic, they are the least desirable places for sidewalk impediments that constrict flow and may result in pedestrian overflow into vehicular spaces.

Pedestrian facilities should be designed to provide for pedestrian flows and the storage of pedestrians waiting to make their desired street crossing. It is desirable not to locate parking spaces, poles, mail boxes, bus stop shelters, planters, trees and similar items near crosswalks where they may obscure pedestrians and the handicapped from the motorists' view and decrease pedestrian storage and queuing areas.

Where there are heavy concentrations of pedestrians, the storage area and crosswalk areas should be calculated. Chapter 13 of the Highway Capacity Manual (TRB Special Report No. 209) contains the necessary equations, and explanations, for making these calculations.

Intersections, particularly signalized intersections, are the most complex part of the road network for pedestrians. There are 32 possible vehicle to pedestrian conflicts at the 4-way intersection of two roads. Many occur at high speeds.

It is preferable that intersection areas (conflict zone) be as small as possible to reduce the:

- unused pavement
- pedestrian to vehicle exposure
- pedestrian crossing distance

These practices make the vehicle paths clearer and reduce the relative speed between opposing movements. Channelization with medians, and right turn slip lanes with channelization islands can reduce the conflict zone and provide safe refuges for pedestrians, when wider intersection areas are required to accommodate wide curb radii or multiple turning lanes. Turning movements which are dangerous to pedestrians can be prohibited.

Right-turn-on-red (RTOR) has been demonstrated to increase pedestrian accidents. The person most at risk is the pedestrian crossing from the right to the left in front of a driver. Drivers focus their attention to the left and can start to turn before noticing the pedestrian on the right. Sixty-seven (67) percent of RTOR/pedestrian accidents involve this movement.

Roundabouts can be an effective treatment for reducing vehicle speeds in residential neighborhood streets. Lower vehicle speeds can facilitate pedestrian crossings and substantially reduce stopping distance.

a. Policy Recommendations

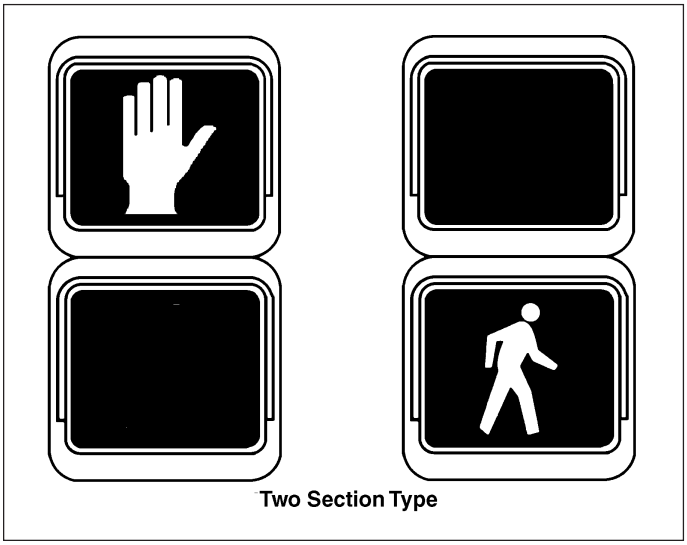
1. Prohibit Right-Turn-On-Red at those intersections where pedestrian volumes are significant and field studies suggest this treatment.
2. Provide a median with a pedestrian refuge area whenever the crossing distance exceeds 18 meters (60 feet). Pushbuttons should be installed in the median and handicap ramps or a full cut should be provided through the median. Refuge islands should preferably be at least 1.8 meters (6 feet) in width and in no case less than 1.2 meters (4 feet) wide to reduce the danger to island users, particularly those in wheelchairs propelled by attendants, from projecting into the traffic lanes. Additional guidelines for refuge islands are provided in Sections 5 and 6.

3. Where warranted, install pedestrian buttons in accordance with DOT Standard Index #17784 in a standardized manner at all signalized crosswalks and in medians. Pushbuttons should be installed on separate poles according to illustration. This enables use by handicapped and sight impaired users and reduces the con-

fusion normally associated with these devices for the general population.

4. Pedestrian signal heads should be installed at urban signalized intersections, when field studies warrant. Install pedestrian signals on the poles that support the pushbuttons so they relate to the signal display. If the distance between the pedestrian signals across the road is greater than 18 meters (60 feet), another pedestrian signal should be installed in the median if possible. This will enable elderly and sight impaired pedestrians to see the signalheads. All signalheads should be brought up to current standards shown in MUTCD Figure 4-3, page 4D3. These standards specify the use of white and Portland orange colors only, since elderly pedestrians may have difficulty distinguishing color differences on the non-standard signalheads. Symbols should be used instead of words as the illustration in Figure 17 depicts.
5. Where possible, move existing drainage structures and install new structures out of the curb radius to prevent pedestrians from design-induced tripping. Drop inlets should be installed on the upstream side of corners to prevent large volumes of water flowing around the corner. Where an inlet is not provided, the gutter must be designed to carry water away from the pedestrian crossing even when the gutter is snow covered.
6. When diagonal spans supporting traffic signalheads would prevent pedestrians from seeing the current vehicle phases, convert existing spanwire installations and install new traffic signal installations using pole/mast arm mounted signals or box spans.
7. Parking should be prohibited within 18 meters (60 feet) of the approach to, and 9 meters (30 feet) on the departure from, a signalized intersection. Vehicles parked close to an intersection block a driver's view of pedestrians. Design of streetscape improvements should prohibit furniture, plantings, etc., which create visual screens.
8. On streets with parking, provide full corner and half corner sidewalk flares (bulbouts). See Figure 18. This rarely reduces vehicle capacity, yet allows more pedestrian queuing space, provides the pedestrian with a shorter crossing distance, and increases pedestrian visibility. The concept has been widely applied in older downtown areas in conjunction with revitalization and streetscape improvement efforts, but it is equally applicable to new roads, under the appropriate conditions.

   Sidewalk flares (bulbouts) tend to slow traffic at intersections or at mid-block locations by reducing the effective width of the street. The extent to which traffic is slowed depends on the design. Bulbouts should not infringe upon or restrict the roadway width required to accommodate bicycle traffic.

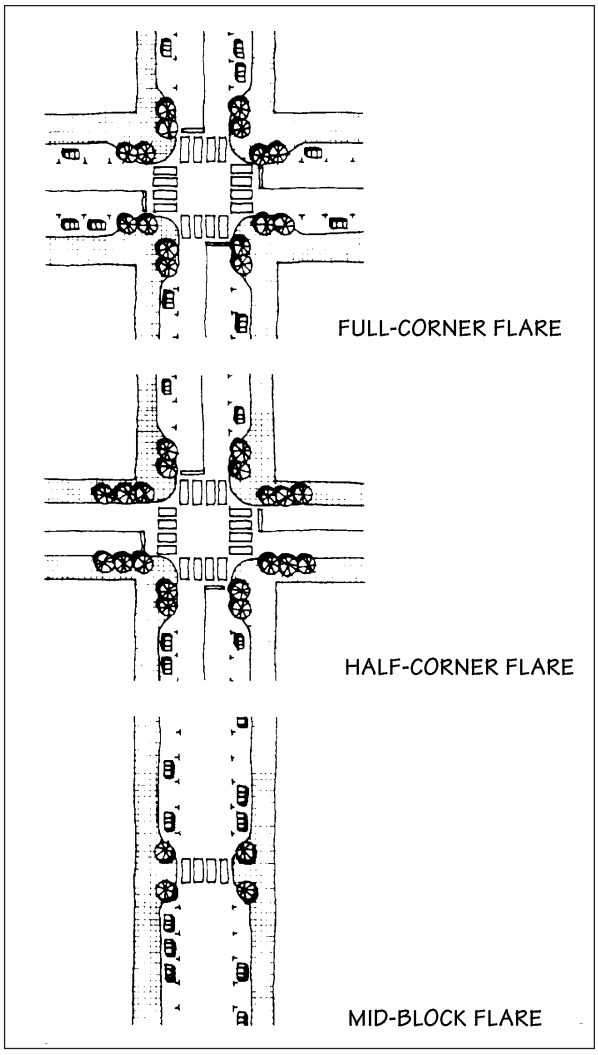


Source: Manual on Uniform Traffic Control Devices, 1988

Figure 17
Pedestrian Signal Face Designs

Figure 18

Alternative sidewalk flare designs



Source: Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas, Transportation Research Board, 1987

Turning movements by trucks and buses are often facilitated by the added roadway width provided by the parking lane. Therefore, when installing sidewalk flares, care should be used in providing adequate curb radii where it is important to maintain truck and school bus access. Required curb radii vary by the cross section of the intersecting streets.

On roads where parking occurs intermittently, adequate delineation of the flares is needed to keep vehicles from straying into the parking lane and crashing into the flare area.

Mid-block crossings are not normally installed if an intersection is within 120 meters (400 feet) of the proposed mid-block location, but should be considered where a need is apparent or where pedestrian behavior will dictate such crossings. Other speed control measures such as speed tables may be used in conjunction with this treatment to help reduce conflicts between pedestrians and vehicles.

9. Whenever possible, locate bus stops on the departure (far) side of the intersection so that the bus does not screen departing passengers from the traffic as they cross the street.

10. When the approaching drivers' view of pedestrians is restricted, clean-up the corner by using joint-use poles to support traffic signals, street names, light-

ing, and signs. Relocate or remove all other items or trim trees or shrubs.

11. When there is inadequate pedestrian walk and clearance time, re-time existing and new signals to ensure adequate crossing time for pedestrians. Signals frequently used by elderly or physically impaired persons should be re-timed to provide a crossing time commensurate with their ability.

b. Planning Considerations

Many signalized intersections are unfriendly to pedestrians because of the speed and complexity of vehicle movements and the number of lanes added for capacity. Future planning and project development should:

- Include the use of traditional neighborhood developments and grid systems to provide pedestrians with multiple crossing opportunities and to spread out vehicle turning movements.
- Use one-way pair streets, slip lanes and medians to reduce the number of lanes to be crossed.
- Prohibit left turns in downtown or commercial zones or where high concentrations of elderly pedestrians are present if analysis indicates that conflicts between pedestrians and turning vehicles is creating a safety or capacity problem. In some situations, protective phase left turns can mitigate these conflicts.
- Consider roundabouts on collector roads and minor arterials at intersections in residential neighborhoods since they effectively reduce vehicle speed and pedestrian/vehicle conflicts.

Factors affecting the danger to pedestrians by right turning vehicles include the number of turning lanes, turning volume, turn radius and distance from start of turn to crossing pedestrian. If there is little occasion for trucks to turn, current AASHTO guidelines permit 4.5 - 7.5 meters (15 - 25 foot) turning radii on minor streets. AASHTO further permits the use of a 12 meter (40 foot) turning radii on major streets if the occasional truck can turn with little encroachment. Radii of 12 meters (40 feet) or more are only recommended when large trucks or buses turn frequently. In these situations, right turn slip lanes should be considered, as they will provide a better operating environment for the large vehicle and the pedestrian.

Wherever turning volume and traffic types warrant, construct a right turn slip lane. Double right turn lanes are very dangerous for pedestrians because the vehicle in the inner lane blocks the vision of the driver in the second lane.

5. Medians

Medians should be provided as a standard feature of multi-lane suburban highways. Multi-lane highways with medians are substantially more convenient for pedestrians to cross than comparable highways without medians. This is particularly true at mid-block locations or unsignalized intersections, where medians can greatly simplify the pedestrian's task of crossing the street.

A pedestrian crossing an undivided street must wait until adequate gaps are available in both directions of travel. With a median, the pedestrian may treat each direction of travel as a separate crossing movement. The delay in crossing the road without a median can be as much as 10 times the delay incurred while crossing with a median. The heavier the traffic volume, the more important a median becomes in facilitating street crossings.

A median of at least 2.4 meters (8 feet) in width should be included on all new or reconstructed arterial and collector highways of four or more lanes to accommodate pedestrians in refuges. Wider medians are not necessarily needed for pedestrian crossings, but may be desirable for greater vehicular separation and accommodation of turning lanes, where jughandles are not provided.

If driveways are frequent and a service road cannot be provided, periodic median breaks still provide for adequate vehicular access while enhancing pedestrian convenience and safety. Figure 19 shows an example of a median with periodic openings for vehicular access. Some of the median segments are little more than pedestrian refuge islands, but they add greatly to the channelization of pedestrian and vehicular flows.

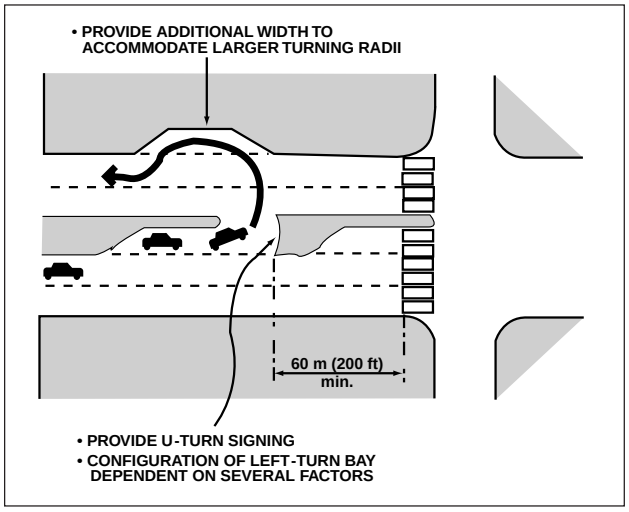
If access to all the driveways cannot be accomplished through direct median breaks and jughandles are infeasible, provisions can be made to permit U-turns. The most difficult situation in which to accommodate U-turns is a four-lane highway with a narrow median. Many vehicles cannot turn within the space provided, but provisions can be made to widen the far-side pavement to provide the required space, as illustrated in Figure 20. The median break for U-turns should be provided away from intersections and driveways (i.e., should be for the exclusive use of U-turns to minimize driver attention demands and to avoid driveway traffic conflicts), at least 60 meters (200 feet) upstream of an intersection.

Figure 19

Application of short median segments to a wide arterial street

Figure 20

Example Application of Provision for U-Turns when Median is included



Grass medians are preferred, but concrete medians are acceptable if there are overriding considerations of maintenance costs or other factors. For grass medians, paved walkways should be provided at all locations where pedestrian crossings are expected and especially where paths across the median are evident. These will primarily occur at intersections. Ideally, breaks in the median should be provided so that pedestrians can cross at street level (Figure 21). However, on medians sufficiently wide enough to accommodate a pair of curb ramps, a median-level walkway with properly designed curb ramps (Figure 22) may be preferred to more effectively accommodate mowing operations and to prevent ponding in the pedestrian walkway. This usually requires a median width greater than 4.8 meters (16 feet).

Figure 21

Median Opening to Accommodate Street-Level Pedestrian Crossings

Source: Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas, Transportation Research Board, 1987

In areas where a continuous median is, for some unusual reason, impractical to include in new roadway construction, efforts should be made to place pedestrian refuge islands at strategic points along the highway. Most refuge islands must be at least 1.2 meters (4 feet) wide, and 3.0 meters (10 feet) long, and should be well signed, marked, and lighted. These may be needed where intersection areas are large and crossing distances great. Guidelines for refuge islands are addressed in Section 6.

Source: Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas, Transportation Research Board, 1987

Figure 22
Well-Designed Elevated Median Crossing

On existing, undivided four-lane roadways, consideration should be given to re-striping the roadway to provide a lane for left turns, one through lane in each direction plus a shoulder. The center left turn lane will not provide the pedestrian with the same physical protection as a median. However, it does provide an area outside of the traffic stream, allowing the pedestrian to cross the roadway in two movements rather than one. This type of cross-section also reduces the crossing width for pedestrians and improves sight distances for both motorists and pedestrians.

6. Crosswalks, Curb Ramps and Refuge Islands

a. Crosswalks

For marked crosswalks to provide their maximum pedestrian safety potential, it is important that they be installed only where needed. The motorist may lose respect for all pedestrian regulations and traffic controls if marked crosswalks occur at a large number of intersections where the motorist rarely encounters pedestrians. Due to the associated safety consequences, the cost of installation and the continued cost of maintenance, crosswalks should be considered primarily for the following locations:

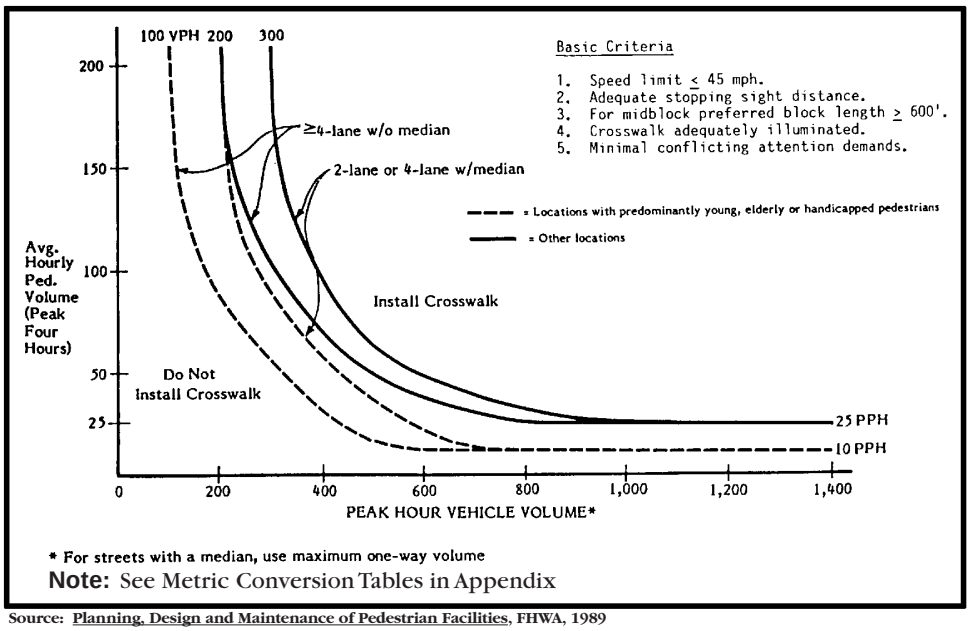
- All signalized intersections with pedestrian signal heads.
- All locations where a school crossing guard is normally stationed to assist children in crossing the street.
- All intersections and mid-block crossings satisfying the minimum criteria in MUTCD. As long as the basic criteria governing sight distance, speed limit, etc., are met, a crosswalk is deemed appropriate if the pedestrian and vehicular volumes place it above the appropriate curve in Figure 23. Each crosswalk is analyzed by approach leg, indicating that a crosswalk might be warranted on one side of an intersection and not the other. Thus, the guidelines might suggest that only one crosswalk need be marked at a given intersection. If each approach warrants a crosswalk, then all should be marked.
- All locations within 0.4 kilometers (1/4 mile) of transit stations or schools.
- Situations where a dedicated pedestrian trail crosses a highway at a mid-block location and pedestrian traffic would not otherwise be anticipated.
- All other locations where there is a need to clarify the preferred crossing location when the proper location for a crossing would otherwise be confusing.

- Locations in both urban and non-urban areas where development on both sides of a highway results in concentrated pedestrian volumes crossing the highway and there is no highway intersection (e.g., where a large parking lot is on the opposite side of the road from a campus or manufacturing plant or where shopping or eating areas are across the road from workplace areas).

Suburban areas will generally not reach the pedestrian volumes which justify crosswalks in Figure 23. In suburban areas, professional judgement must be applied to the pattern of existing and future land use to assess if these patterns, rather than volumes, should warrant a crosswalk. For locations where a significant proportion of the pedestrian population are the young, elderly or handicapped, the volume thresholds should be reduced by a value of 50% or more.

Figure 23

Guidelines for Crosswalk Installation at Uncontrolled Intersection Legs, Midblock Crossing, and Signalized Intersections without Pedestrian Heads

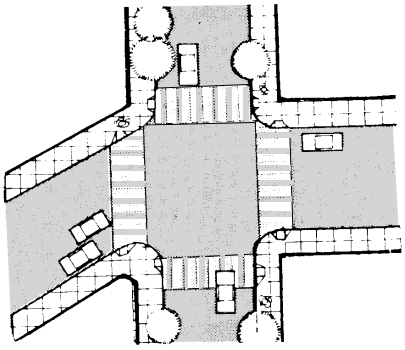


Source: Planning, Design and Maintenance of Pedestrian Facilities, FHWA, 1989

Crosswalks are usually marked in the immediate vicinity of intersections. Proper design of mid-block crossings requires that special consideration be provided for prohibiting parking, ensuring adequate sight distance for both pedestrians and motorists and advance warning for motorists of mid-block crossing presence. Mid-block crossings are not normally installed if an intersection is within 120 meters (400 feet) of the proposed mid-block location.

If the warrants as set out in the MUTCD Section 4C-5 are met or if field studies warrant, then a signalized pedestrian crossing may be desirable. However, consideration should first be given to provision of a refuge island and an unsignalized crossing. A refuge may not be appropriate because the traffic volumes are very high, the road too narrow to construct a refuge, or special pedestrian needs may exist. If blind, very young, elderly or handicapped pedestrians are to be regular users of the crossing, their needs must be given special consideration. When crossings are to be installed, they must be installed on the pedestrian desire line.

Crosswalks should, whenever possible, be installed so that they form 90° angles with the curb. Perpendicular (90°) crosswalks minimize the walking distance and, therefore, the pedestrian exposure to vehicle conflicts. They also better accommodate the needs of blind pedestrians who are usually accustomed to perpendicular crossings. Crosswalks intersecting the curbs at other than 90°, as indicated in Figure 24, should be avoided whenever possible. If it is not possible to avoid an angled crosswalk, then at least one of the marking lines should be retained at 90° to the curb. When it is necessary to use angled crosswalks, the pavement marking that indicates the edge of the crosswalk should be comprised of material that is detectable to the visually impaired using long cane techniques.



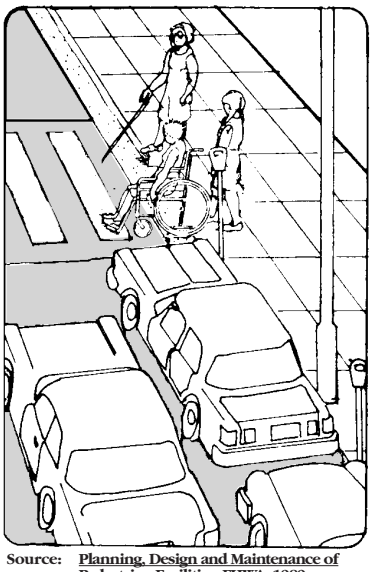
Crossings that do not make 90° angles with the curb should be avoided whenever possible.

Source: Planning, Design and Maintenance of Pedestrian Facilities, FHWA, 1989

Figure 24

Crosswalks Intersecting Curbs at other than 90 degrees

Parked vehicles can pose visual obstructions both for pedestrians and motorists. Children, wheelchair occupants or individuals of small stature present a special risk, as illustrated by Figure 25. Parking should be prohibited within 6 meters (20 feet) of the nearest crosswalk and within 6 meters (20 feet) of an intersection if a crosswalk is not provided.



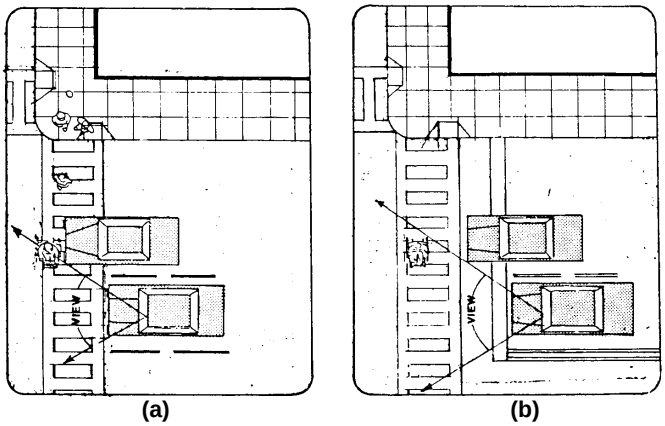
Source: Planning, Design and Maintenance of Pedestrian Facilities, FHWA, 1989

Figure 25

Examples of Undesirable Visual Obstruction Resulting from Parked Vehicles

Stop Lines

The installation of stop lines at crosswalk locations controlled by traffic signals or stop signs is effective in reducing vehicle encroachments on the crosswalk. The stop lines should be placed 1.2 meters (4 feet) in advance of and parallel to the crosswalk. See Figure 26.



(a) (b)

Typical vehicle encroachment and resultant sight restriction occurring without stop lines (a) and benefits of stop line installation (b).

Source: Planning, Design and Maintenance of Pedestrian Facilities, FHWA, 1989

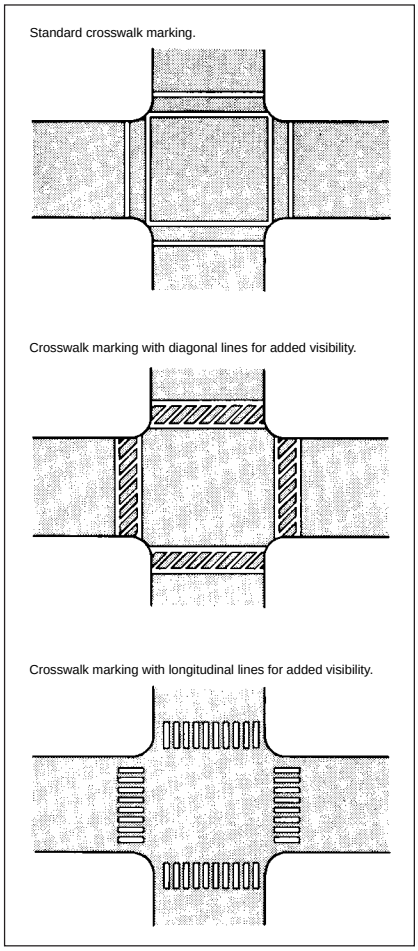
Figure 26

Installation of Stop Lines at Crosswalk Locations

Markings

Crosswalks should always be at least as wide as the sidewalk and should never be less than 1.8 meters (6 feet) in width. A 3.0 meter (10 foot) crosswalk width is preferable.

Figure 27
Typical Crosswalk Markings



Source: Handbook on Planning, Design and Maintenance of Pedestrian Facilities, FHWA, 1989

Crosswalks must be clearly discernible to pedestrians to guide them in their proper path, and to motorists to warn them of the pedestrian crossing point. Crosswalk lines are solid lines at least 150mm (6") in width and not less than 150mm (6") apart that mark the boundaries of the path pedestrians should use to cross the roadway.

The primary types of crosswalk markings are presented in Figure 27. The white diagonal lines, at a 45° angle, or the white longitudinal lines, at 90°, are used to provide added emphasis to the motorist. The diagonal and longitudinal lines should be 305-610mm (12-24") in width and spaced 305-610mm (12-24") apart. When they are used at an intersection, it is permissible to omit the transverse crosswalk lines. The diagonal and longitudinal lines are intended for use at locations that have a substantial number of pedestrians crossing without any other traffic control device present, at locations where added visibility of the crosswalk is desired or at places where a pedestrian crosswalk is unexpected. Mid-block and other non-intersection crossings are often treated with diagonal or longitudinal lines.

Obstructions

Manhole covers, gratings and other access covers should not be located within crosswalks. If it is not possible to avoid their location within crosswalks then they must be readily visible and made slip-resistant.

Illumination

Crosswalk illumination can substantially enhance pedestrian safety during darkness. Vehicle headlamps often do not provide sufficient illumination to permit the motorist to identify the presence of a pedestrian in sufficient time to take the necessary evasive action. Special or additional street lighting may be required to assure that the pedestrian is adequately lit. Street lighting should be designed to ensure that the light is reflected off the pedestrian to driver's eyes. In general, illumination should be considered as warranted when the night visibility requires lighting in order to provide the mutual sight distance capabilities described as necessary in AASHTO. Specific locational characteristics that should be considered for crosswalk and general intersection illumination include:

- Roadways that have a speed limit in excess of 65 km/h (40 mph) that do not

provide adequate pedestrian conflict elimination.

- Intersections, access and decision points and areas adjacent to changes in roadway alignment and cross section.
- Bus stops and crossings servicing rail stations or other mass transit transfer locations.
- Areas adjacent to pedestrian generating centers and parking lots.
- Refuge islands, including their approach-end treatment should be sufficiently illuminated to show the general layout of the island and immediate vehicular travel paths. The greatest concentration of illumination should occur at points of possible danger to pedestrians or vehicles, as at barrier curbs or other structures.
- Any location where problems associated with nighttime visibility has resulted in more frequent vehicle-pedestrian conflicts.

Where warranted, the lighting levels in pedestrian areas should meet those recommended by the Illuminating Engineering Society (IES). See Table 6.

Table 6
Recommended Pedestrian Crosswalk Illumination.

Pedestrian Walkways	Commercial		Intermediate		Residential	
	Footcandle	Lux	Footcandle	Lux	Footcandle	Lux
Sidewalks	0.9	10	0.6	6	0.2	2
Pedestrian Walks*	2.0	22	1.0	11	0.5	5
Building Sites			Values are given in minimum average maintained horizontal footcandles and lux.			
Entrances	5.0	55				
Grounds	1.0	11				
Parking Areas						
Self Parking	1.0	11				
Attendant Parking	2.0	22				

*** Crosswalks traversing roadways in the middle of land blocks at street intersections should be provided with additional illumination producing from 1.5 to 2 times the normal roadway lighting level.**

b. Curb Ramps

Regulations of the Architectural and Transportation Barriers Compliance Board require that a ramp or curb ramp be provided anywhere there is an abrupt grade change greater than 13 millimeters (1/2 inch), or anywhere that the slope of an accessible pedestrian route is greater than 1:20, if no other means of accessible vertical access is provided.

Ramps and curb ramps were originally required to assure that buildings and facilities would be accessible to the disabled, and especially to persons in wheelchairs. However, the construction of these facilities quickly demonstrated that they could provide benefits to almost all pedestrians. Vertical changes in a pedestrian route pose a serious constraint and hazard for all pedestrians, not just persons using wheelchairs. Trips and falls associated with vertical changes are a common cause of injuries ranging from sprained ankles to broken bones and head injuries. Assuring that a change of grade is negotiated safely requires pedestrians to significantly slow down, reducing pedestrian capacity. Vertical steps require substantially more energy than normal walking, both in climbing and descending. Single steps, including steps off of curbs, are especially dangerous for pedestrians.

Curbs and other vertical obstructions along a pedestrian route can block the route for all wheeled vehicles, not just wheelchairs. Removal of these obstacles, through the

construction of ramps or curb ramps, will, therefore, also assist pedestrians pushing or pulling luggage carts, baby carriages or strollers and any other wheeled vehicles used by pedestrians. The provision of curb ramps and other pedestrian facilities that eliminate the need to negotiate steps and stairs has substantially expanded the number of walking opportunities available to the population as a whole, making walking a more viable means of transportation.

Numerous studies have demonstrated that where ramps or curb ramps have been provided along pedestrian routes, they are used by most pedestrians. Joggers, hurried commuters, children and the elderly will seek to use an available curb ramp in lieu of stepping over a curb, provided that the ramp is conveniently situated. Similarly, most pedestrians prefer to use ramps in lieu of steps, if the ramp is conveniently located and provides adequate capacity. Ramps and curb ramps especially benefit persons with arthritis or other disabilities which limit one's ability to negotiate vertical changes. As a result, these pedestrian facilities, originally provided to assist persons in wheelchairs, have been demonstrated to provide a major benefit to a broad cross section of the population.

Where provided, ramps and curb ramps should be designed to accommodate all pedestrians and should be located so that they are convenient. Minimum standards required to serve the needs of persons in wheelchairs seldom provide sufficient width to accommodate all pedestrians efficiently and may result in delays at intersection locations and hazards as a result of cross slopes along edges bounding the remainder of the sidewalk. As a result, ramps should be constructed with substantially wider widths than the minimums required by regulation.

Needs of Visually Impaired Persons

Curb ramps present special problems for visually impaired persons. Most severely affected are blind persons who are accustomed to using curb edges as a cue for the presence of a public street. Provision of a curb cut eliminates this traditional cue and can expose a blind person to the hazard of walking directly into a street with vehicles. As a result, curb ramps are now required to incorporate some form of detectable warning to alert blind persons that they are entering a street.

Blind persons also use the curb as a device to direct them into the adjacent crosswalk which they assume runs perpendicular to the curb face. Locating curb ramps along the curb corner can direct a blind person or a visually impaired person into the middle of a street intersection rather than into the crosswalk. As a result, where possible, curb ramps should be designed to protect against this hazard.

Locations Requiring Curb Ramps

A public sidewalk curb ramp with a level landing shall be provided wherever a public sidewalk or public pedestrian easement crosses a curb or other change in level. Examples of places which require the provision of a curb ramp include:

- intersections,
- painted crosswalks at mid-block locations,
- crosswalks at exit or entrance ramps,
- driveways,
- channelized islands or divisional islands, and
- median islands at mid-block locations.

The landing of a curb ramp consists of a level area at the top or bottom of a ramp run provided to allow a person in a wheelchair to change directions. Landings also provide a waiting area for pedestrians and wheelchair users. To accommodate the needs of a turning wheelchair, landings must consist of an area at least 1220 millimeters (48 inches) wide on all sides. Because landings are located at street intersections, it is often desirable to provide substantially wider landing areas to accommodate both moving and waiting pedestrians. The slope of a landing shall not exceed 1:50.

Types of Curb Ramps

There are four general methods of constructing curb ramps: perpendicular, parallel, diagonal or projected. Figure 28 illustrates the first three methods.

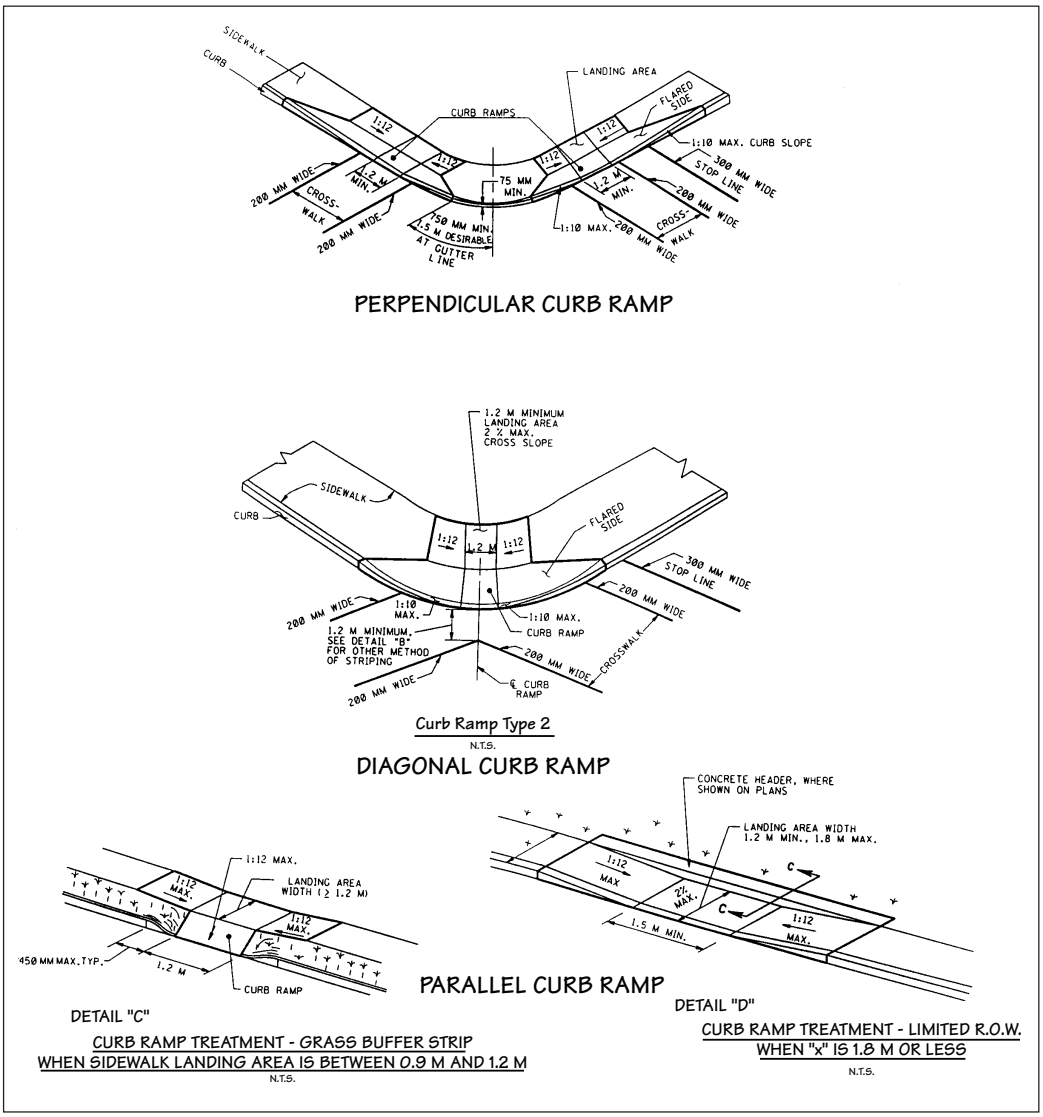
A perpendicular curb ramp runs perpendicular to and cuts through the curb. It connects to a street crossing at the bottom of its ramp run and to a landing at the top of the run. Perpendicular curb ramps are the generally preferred method of accommodating a grade change, provided that adequate right-of-way is available for its construction.

A parallel curb ramp runs parallel to the curb and consists of a ramped section of a sidewalk. It connects to a landing at the bottom of its run. The landing of a parallel curb ramp connects to the street crossing.

A diagonal curb ramp is located at the midpoint of a curb radius and runs perpendicular to and cuts through the curb. Because of its location on the midpoint of the curb radius, the axis of a diagonal curb ramp extends diagonally across the intersection of two intersecting streets. A diagonal curb ramp serves each of two intersecting street crossings at a corner. Because diagonal curb ramps direct pedestrians diagonally into the street intersection, they are generally discouraged in new construction except when they connect with a channelizing island located between a right turning roadway and the main portion of the intersection.

A projected (or built up) curb ramp consists of a perpendicular curb ramp constructed in part by extending the curb ramp into the gutter portion of the roadway (not illustrated in Figure 28). In existing locations where right-of-way is extremely limited, projected curb ramps may be the only method of accommodating the slope required for a curb ramp. A projected curb ramp can result in a reduced slope both because it allows for a longer curb ramp and because the total vertical change required is less. However, the projection of the curb ramp into the street can create drainage problems and may subject the ramp to damage from street cleaning equipment and from turning vehicles. Projected curb ramps may also encourage pedestrians to enter into the roadway prematurely. As a result, projected curb ramps are discouraged and should only be allowed when no other method of providing a curb ramp is available. When provided, a projected curb ramp should not extend into the moving traffic lane.

Figure 28
Types of Curb Ramps



Source: Standard Roadway Construction Details, NJDOT

Width of Curb Ramps

The minimum width of a curb ramp required by ADA regulations is 915 millimeters (36 inches), the width required to accommodate a wheelchair. On NJDOT projects, a minimum width of 1220 millimeters (48 inches) is required. However, because most pedestrians would prefer to make use of a curb ramp if it is available, it is generally preferable to provide a curb ramp which extends for the full length of the unobstructed pedestrian circulation path. The width of the curb ramp does not include the width of any flared sides required to raise the sides of the curb ramp back to the surrounding grade.

Slope of Curb Ramps

The minimum feasible running slope shall be provided for any public sidewalk curb ramp and shall be measured from a level plane. The maximum running slope of any curb ramp shall be 1:12, and the maximum cross slope shall be 1:50.

Edges

Where a side of a perpendicular curb ramp is contiguous with a sidewalk, it shall be flared with a maximum slope of 1:10. A perpendicular curb ramp may have a returned side or flare of any slope when not contiguous with a sidewalk or where the sidewalk is protected by a guardrail or other barrier. Because the introduction of the flared edge represents a safety hazard for pedestrians and persons in wheelchairs, it is preferable to avoid them through the use of curb ramp designs which do not place curb ramps next to sidewalks. This can be accomplished through the use of wide sidewalk set back areas or through the construction of extended street corners or bulb-outs.

Surfaces

The surface of a curb ramp should be stable, firm and slip resistant. Gratings and similar access covers should not be located on curb ramps or landings. The surface of a perpendicular curb ramp or the landing of a parallel curb ramp should contrast visually with adjoining sidewalk and roadway surfaces. To alert blind persons of the presence of the curb ramps, curb ramps should have a detectable warning material extending the full width and depth of the curb ramp.

Relationship to Crosswalks

When located at an intersection with marked crosswalks, the curb ramp should be wholly contained within the crosswalk markings. Crosswalk markings should be adjusted to accommodate the curb ramp as needed.

Transitions

Transitions between the curb ramp and the sidewalk and between the curb ramp and the street and gutter shall be free of abrupt changes. Counter slopes of adjoining gutters and road surfaces, connecting to the full width of a curb cut shall be a maximum of 1:20 for a distance of 610 millimeters (24 inches) as measured from the base of the curb ramp or landing edge at the street. Gratings or similar access covers shall not be located in the area at the base of the curb ramp or landing.

Obstructions

Curb ramps should be located or protected to prevent their obstruction in the street by parked vehicles or stopped buses. When necessary, bus stop locations should be moved away from the corner of an intersection a sufficient distance to assure that stopped buses will fully clear the curb ramp and crosswalk area.

The curb ramp and landing area should be kept clear of all obstructions such as light standards, traffic signals, meter boxes, controller boxes, junction boxes, utility poles, inlets, fire hydrants, guide rail, signs, planters, etc. Existing obstructions should be relocated as necessary so as to provide maximum visibility of pedestrians by motorists.

Drainage

Wherever possible, drainage inlets should be installed upstream of the bottom of the run of any curb ramp to remove as much drainage as possible from the gutter in the crossing area. Curb ramps should be located to avoid any drainage low points in the gutter grade. In new construction or major reconstruction of the street, gutter or intersection, the gutter should be pitched to draw water away from the pedestrian crossing.

Islands

Islands can assist pedestrians when crossing the street if they are designed to provide refuges and result in shorter roadway crossing distances. To be effective for this purpose, islands should be designed to facilitate pedestrian crossings. Where islands exist or are proposed at intersections with curb ramps, the following provisions shall apply:

(1) Where a small, raised channelizing island already exists at an intersection, it is not necessary to provide for a curb ramp or walkway opening for the island, but crosswalks should be adjusted to safely accommodate a person with disabilities without encroaching into the adjacent traveled way. Where a new island is proposed, it should be designed in accordance with paragraph 2 below.

(2) For larger channelizing islands, provide a 1.2 meter (four foot) wide walkway opening level with the street in the part of the island intersected by the crosswalk. In most cases, where larger channelizing islands are provided for right turns, the most effective crosswalk design will be to provide a diagonal curb ramp from the sidewalk to the island and then two perpendicular crosswalks from the island across each of the intersecting highway approaches. The refuge area within the island should be large enough to accommodate waiting pedestrians and to allow wheelchair users to adjust their direction of travel.

Except for very large islands, the slope required for a pair of curb ramps will prohibit introduction of a raised landing and refuge area as part of the island. However, where the walkway opening in the island would be long or would create drainage problems, it may be appropriate to place curb ramps at all sides of the island where it is intersected by crosswalks and have a level landing area of at least 1.5 meters (five feet) square between the curb ramps.

(3) At intersections where a left turn island or divisional island is encountered and the island cannot be moved back so that the nose is out of the crosswalk, provide a walkway opening level with the street in the part of the island intersected by the crosswalk. A minimum width of 1.2 meters (four feet) is required if the island is to serve as a refuge for pedestrians. Preferably a 1.8 meter (6 foot) width should be provided to protect a person pushing a stroller or wheelchair or to accommodate a person pushing a bicycle.

(4) At mid-block locations where a crosswalk intersects a median, an opening at least as wide as the crosswalk, but no narrower than 1.5 meters (5 feet), shall be provided in the median island. For medians wider than 3.6 meters (12 feet), a curb ramp may be provided at each side of the median island leading to a landing in the center of the median at least 1.5 meters (5 feet) in length. In wide median islands, this landing may be located at curb height; on narrower median islands, the landing may only be 25-50 millimeters (one or two inches) above the elevation of the roadway. In general, with wider median islands, maintenance of the pedestrian passage and of the island's landscaping will be facilitated through the provision of curb ramps and a raised landing area.

Sight Distance

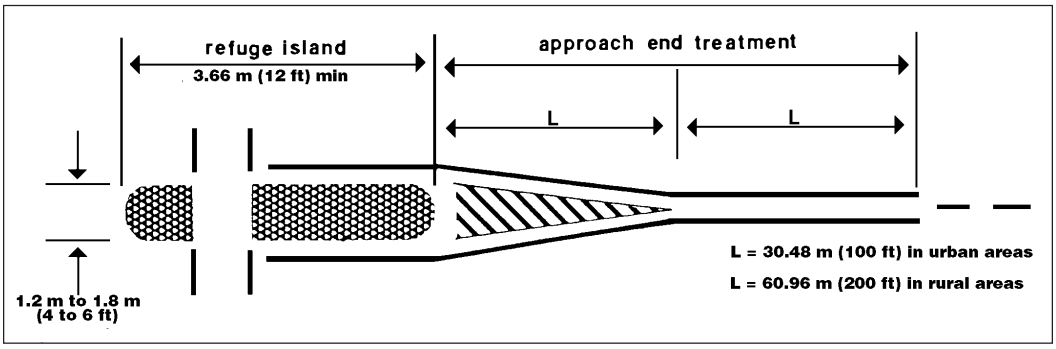
The sight distance at street crossings should be checked to ensure that curb ramps are not placed in such a location that a motorist will find it difficult to perceive the low profile of a wheelchair occupant crossing the roadway. Where necessary, parking controls should be enacted to prevent parked cars from blocking a motorists view of a person in a wheelchair.

c. Refuge Islands

Refuge islands were mentioned in the Section 5 on Medians. They are also an important element in Section 8, Upgrading and Retrofitting Existing Highways. This section provides specific design criteria for refuge islands.

Refuge islands should preferably be at least 1.8 meters (6 feet) wide, and in no case less than 1.2 meters (4 feet) wide, to reduce the possibility of island users, particularly those in wheelchairs propelled by attendants, from projecting into the traffic lanes. Refuge islands narrower than 1.8 meters (6 feet) often create a feeling of isolation and unease in pedestrians due to the proximity of moving vehicles. The length of the refuge island should not be less than 3.6 meters (12 feet), or the width of the crosswalk, whichever is greater. A diagram depicting the size and shape of refuge islands is presented in Figure 29.

In general, islands should be designed to minimize the potential hazard to both motorists and pedestrians. In areas of high traffic volumes, refuge islands are more visible to the motorist and safer for the pedestrian if their noses are raised and outlined with barrier curbs.



Source: Planning, Design and Maintenance of Pedestrian Facilities, FHWA, 1989

Figure 29
Minimum Size and Shape Requirements of Refuge Island

Object markers should be used on the island approach noses to indicate the presence of the raised curb.

Where the refuge island is too narrow to provide the required slope for a curb ramp plus a 1.2 meter (4 foot) level landing, then the crosswalk must continue through the island at roadway level. If the walkway surface of the refuge island is maintained at the same level as the crosswalk, then special provisions for the visually impaired should be provided to assist them in identifying the location of the refuge island. This can be accomplished by providing appropriate tactile clues that can be detected by long cane techniques.

The refuge island should be sufficiently raised to assure that water will not pond in the refuge area. Ideally, drainage inlets should be provided along the median upstream of the pedestrian refuge, or else the roadway should be pitched away from the median.

7. Overpasses and Underpasses

In urban areas, pedestrian overpasses or underpasses may provide an appropriate method of facilitating pedestrian crossing of freeways or high volume arterial highways. They are not appropriate for widespread application in suburban, fringe or rural areas. While separation of pedestrians and vehicles by means of grade separation structures is theoretically the most effective means of pedestrian protection, grade crossing structures are expensive to construct and maintain, and unless properly located and designed, will not be used to their full potential.

Grade separation structures require extra effort and travel distance by pedestrians. As a result, pedestrians will frequently attempt to directly cross the traffic stream, despite the safety benefits offered by a grade separated crossing.

a. Planning Considerations

Candidate locations for grade separation include areas where there are "attractors" such as large schools, shopping centers, recreational areas, parking garages or other types of activity centers that are separated by arterials from residential "generators". Locations where there are natural or man-made barriers which would encourage right-of-way and approach structure requirements, are more advantageous than level open sites. Generally, there is more potential for cost-effective applications when overpasses and underpasses are integrated into other land development or highway construction schemes. Where urban cores are undergoing large-scale redevelopment, there exists potential to provide grade separated pedestrian systems as part of the downtown renewal plans.

The location of grade separation structures in relation to other crossing alternatives has a major impact on their degree of use. Experience has shown that the separation will not be used simply because it improves safety. Pedestrians will mentally weigh the perceived safety benefits with the extra effort required. Ideally, the separation structure should be on the normal path of pedestrian movement, increase convenience due to elimination of crossing delays and conflicts and not require the pedestrian to divert long distances. Railings, fencing, and median barriers may be necessary to discourage alternative grade level crossings at alternative locations which pedestrians may believe to be more direct. Barrier design must be continuous to be effective, without gaps which would allow short-cutting the separation structure.

b. Overpasses vs. Underpasses

Overpasses are more commonly used than underpasses with each having inherent advantages and disadvantages. Overpasses require a greater vertical separation than that required for underpasses due to the need to provide adequate clearance for large trucks. The greater vertical height of overpasses generally requires greater right-of-way to provide acceptable ramp slopes and access stair placement. In addition, overpasses, unless enclosed, are open to the weather, exposed to traffic noise and pollution and must be equipped with countermeasures to prevent dropping of debris on vehicles passing underneath.

The underpass clearance height, usually 2.1 to 2.4 meters (7 to 8 feet), can be less than half that of an overpass resulting in shorter stair flights and ramps and reduced right-of-way requirements. The disadvantages to underpass structures include the expense of relocation of utilities, drainage problems and perceptions of insecurity leading to pedestrian avoidance.

The relative elevations of the highway and pedestrian crossing have a significant effect on grade separation cost and potential use. Crossing structure costs and ROW requirements are substantially less at locations where the highway is depressed or elevated relative to the pedestrian crossing. Use of the structure will also be greater at this type of location because fewer stairs and ramps will be needed. The feasibility of underpasses can be improved where it is possible to slope the roadway up over the underpass. Perceived underpass security can be increased by providing wall and roof openings for "daylighting", by high artificial lighting levels, approximately 108 lux (10 footcandles), by avoiding changes in path direction that may produce hidden areas, by consistent maintenance and cleaning and by providing greater horizontal or vertical clearances.

The walking widths should be designed to accommodate the projected pedestrian traffic. If the projected pedestrian density is relatively small, then the walkway width on the structure approaches and on the structure itself should be a minimum of 2.4 meters (8 feet)

to allow sufficient space for wheelchair passing and turning. Minimum clear widths on approach walkways and ramps should be at least 1.5 meters (5 feet) to permit pedestrians to pass and to permit wheelchair passing.

c. Warrants for Pedestrian Over and Underpasses

Most pedestrians will seek to cross a highway at-grade unless a grade separated facility is perceived to be more convenient and direct than the nearest at-grade crossing. As a result, the construction of grade crossings should be limited to locations where traffic volumes provide insufficient gaps to permit safe crossing of the highway, or where the presence of roadway cuts or fill make construction of a pedestrian crossing both less expensive and more convenient for use.

The following warrants, based on an extensive national analysis of how pedestrians use grade crossing facilities, can guide designers on locations where pedestrian structures should be provided on existing highways. On new highways, greater opportunities are available for adjusting roadway grades to facilitate overpass or underpass construction. The warrants are, therefore, inappropriate for new construction or major reconstruction which includes substantial grade work.

Facility Type	Pedestrian Volume	Vehicular Volume	
	Total for 4 hours	Same 4 Hours	AADT
Freeway	100	7,500	25,000
Arterial	300	10,000	35,000

Pedestrian over or underpasses may also be warranted where either the vehicular or pedestrian volume is slightly less than the amount shown, but the other volume is substantially greater.

In addition, a grade separated pedestrian crossing is warranted any time that a safety evaluation of a pedestrian crossing has determined that erection of a fence to prohibit pedestrian crossings is required. Whenever designers feel that measures must be introduced to discourage at-grade pedestrian crossings, a companion project should be programmed to provide an alternative safe crossing on an expedited schedule.

In most situations, a pedestrian structure should not be constructed if a "safe" crossing location is available within 180 meters (600 feet). (A "safe" location could be a signal controlled intersection, a mid-block location either with or without signal control, or another grade separated crossing.)

Exception. A grade separated crossing may still be appropriate despite the availability of a nearby crossing. This is especially likely if the pedestrian demand is substantially greater than the minimum required for the warrant, or if grade differences make installation of an over or underpass especially convenient. Grade separated crossings would be especially appropriate on college or university campuses, at crossings linking recreation areas and schools, at major activity centers, adjacent to train or bus stops or at other unique sites having very high and concentrated pedestrian flows.

d. Conditions for Pedestrian Over and Underpasses

(1) Artificial lighting should be provided to increase the perception of safety on overpasses and in underpasses. Lighting in underpasses should be at least 108 lux (10 foot-candles).

(2) Approaches to pedestrian over or underpasses should be accessible by ramps constructed in conformance with ADA standards. Steps may supplement ramp access, but should not be the principal or most direct means of access.

(3) Pedestrian over and underpasses should be constructed at locations which have minimal elevation differences. Where substantial elevation differences exist, the design for the structure should seek to incorporate earthwork or other structural improvements which will provide pedestrians with the impression that little elevation change is required to cross the facility. Entry into adjoining buildings at basement or second floor level can help to create this impression.

(4) The pedestrian over or underpass should be located to provide pedestrians with the most direct pathway possible.

(5) Where vehicular traffic volumes substantially exceed the volume warrant listed previously, or where unique traffic conditions such as restricted sight distance limit pedestrian safety, consideration can be given to erecting a physical barrier to prohibit at-grade crossings of the roadway by pedestrians. However, in general the designer in these situations should avoid prohibiting at-grade crossings and instead seek to design the over or underpass to be as attractive to pedestrian use as possible.

e. Alternatives to Pedestrian Over and Underpasses

Before constructing an overpass or underpass to service only pedestrians, the following alternative solutions to a pedestrian crossing problem should be considered.

Mid-block crossing — If a median wider than 3.0 meters (10 feet) is available to create a safe pedestrian refuge, an at-grade, mid-block pedestrian crossing may offer an acceptable pedestrian crossing opportunity.

New street crossing — Pedestrians will frequently feel more secure crossing on an overpass or underpass which incorporates a street. The wider width, flatter grades and the presence of drivers can add to the sense of security of such a crossing. Where high pedestrian crossing volumes are present there could also be a latent demand for vehicular crossings. When integrated into the surrounding street network, such a crossing would also provide the pedestrian with better linkages to surrounding land uses.

Widened structure — Frequently stream crossings or railroad crossings can be modified to incorporate a pedestrian facility. Stream crossings are especially appropriate for this purpose since they can often be linked into a greenway plan for the surrounding community. Railroad structures over or under streets can provide a similar opportunity to create a pedestrian crossing. At stations, it may be possible to use an extended platform as the pedestrian crossing.

8. Upgrading and Retrofitting Existing Highways

Many problems of pedestrian convenience and safety are built into the existing highway system. Therefore, significant strides in improving pedestrian safety and convenience must include the upgrading and retrofitting of existing highways.

a. Medians

A median should be incorporated into any project involving the widening of a highway to four or more lanes. There should be exceptions to this rule only if signalized intersections are very frequent, at least every 240 meters (800 feet). If a trade-off must be made between narrow lanes with a median and 3.6 meter (12 foot) standard width lanes without a median, the median option is preferable. All multi-lane undivided highways in developed suburban areas should be considered candidates for median placement.

Figure 30
Retrofitted Striped Median

Source: Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas, Transportation Research Board, 1987

Highway widening should never be allowed to eliminate a sidewalk, even if only on one side. Similarly, every effort should be made not to eliminate shoulders if no sidewalks are available. A three lane roadway with shoulders is preferable to a four lane undivided roadway without shoulders.

Although a 0.6 meter (2 foot) median is a minimum under constricted cross section constraints, at least 1.2 meters (4 feet) is preferred. If existing lane widths on undivided roads are at least 3.6 meters (12 feet), lane widths should be reduced to 3.3 meters (11 feet) to accommodate the median width. If access to commercial establishments is a major factor, provide for frequent median breaks and/or U-turn capability.

A simpler, but less effective, approach to providing medians on existing highways is to provide a 1.2 meter (4 foot) striped median rather than a raised median. An example of this is shown in Figure 30.

b. Refuge Islands

There are many opportunities for using pedestrian refuge islands as a result of their relatively low cost and limited impact on vehicular delay and safety. They should be installed where continuous medians cannot be provided, speeds are generally less than 70 km/h (45 mph), and pedestrian crossing volumes are in excess of 100 persons per day or where pedestrian accidents, particularly those related to roadway width and crossing time, have occurred.

Figure 31
Street-Level Median with Special Refuge Island Delineation

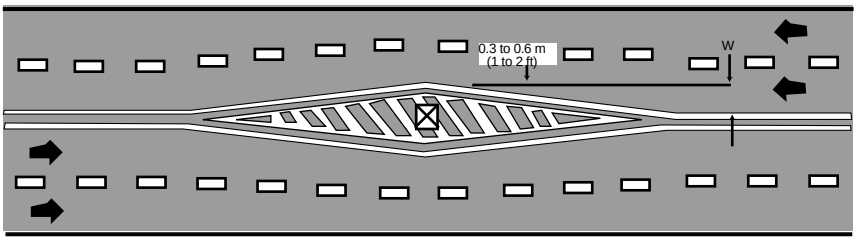
Source: Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas, Transportation Research Board, 1987

Use of refuge islands for mid-block pedestrian crossings across high volume highways where speeds are 70 km/h (45 mph) or more should be carefully evaluated. Such situations may be better served by traffic signals or pedestrian overpasses.

An example of a low-cost refuge area is shown in Figure 31. Although the refuge island is not raised, the stanchions provide a high-visibility holding area for pedestrians. Other types of flexible, high-visibility barriers could be developed to provide a similar function perhaps more attractively.

In some situations, isolated pedestrian refuge islands may be warranted on undivided multi-lane streets. Figure 32 illustrates a recommended striping and signing configuration for a fixed object on an undivided highway. Although not intended for pedestrian refuge

Figure 32
Sample Striping Pattern for Fixed-Object Delineation



Source: Planning and Implementing Pedestrian Facilities in Suburban and Developing Rural Areas, Transportation Research Board, 1987

islands, this same configuration can apply. Installation of this type of refuge may require reductions in lane width or increases in curb-to-curb cross section near the refuge island.

c. Two-Way Left-Turn Lanes

Two-way left-turn lanes (TWLTLs) have been widely applied to facilitate left turns on roads with many access points. Their operational and safety effectiveness has been well-documented for vehicles, but their impact on pedestrian crossings has received little attention.

Although these roadways may be easier to cross compared to undivided multi-lane highways, they are still uncomfortable and potentially dangerous for pedestrians. The pedestrian must carefully observe not only two directions of through traffic, but two directions of left turning traffic simultaneously. Pedestrian crossing demand may be substantial along these roadways, since two-way left-turn lanes are often installed in locations with strip commercial development and near residential areas. There are many 5-lane roadway sections with two-way left-turn lanes, and even some seven-lane sections. Observation of pedestrian activity at two-way left-turn sections indicates that pedestrians often use the middle lane as a refuge. This leaves them vulnerable to both directions of turning traffic.

Solutions to the two-way left-turn lane problem are not easy. The ideal solution is to have a median with frequent openings, but this is not always possible. One alternative is to have a series of carefully placed, well-delineated pedestrian refuge islands. Because of the unique combinations of the number and locations of driveways, each situation must be treated as a special case. In principle, however, islands should be located every 100 to 150 meters (330 to 500 feet). The best way to locate the refuge islands is to plot all turning radii into and out of the driveways from both sides of the road. Nonconflict areas are candidate locations for refuge islands. Refuge islands should be as long as possible without interfering with vehicular turning movements or limiting possible future driveway locations.